# SEISMIC PERFORMANCE OF WATER STORAGE UNDER THE DIFFERENT EARTHQUAKE LOADING

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## SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the bachelor degree in civil engineering.

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## STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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## ABSTRAK

Gempa bumi sering menyebabkan kerosakan teruk kepada bangunan seperti kegagalan ricih dan mod kegagalan ricih lenturan dalam rasuk, kegagalan bersama paksi dalam lajur dan retak yang berkaitan. Tangki air bertingkat adalah salah satu struktur yang terjejas yang disebabkan oleh gempa bumi dan ia perlu berfungsi selepas gempa bumi yang teruk untuk menghadapi kebakaran pasca gempa bumi dan bagi tujuan domestik yang lain. Laporan kajian ini membentangkan analisis dan reka bentuk analisa modal, spektrum respon dan analisis sejarah masa tangki air bertingkat menggunakan SAP2000 sebagai analisis perisian. Tangki air tertakluk kepada beban mati, beban hidup, berat badan dan beban seismik. Pengiraan beban seismik dilakukan dengan mengikuti Eurocode 8 2004. Analisa modal memberikan kekerapan semulajadi struktur dan sejarah masa dimana menentukan tingkah laku struktur dalam interval waktu tertentu terhadap pelbagai fungsi seperti halaju, perpindahan, percepatan, daya ricih, dan momen lenturan.

## ABSTRACT

Earthquakes often cause severe damage to buildings such as shear failure and bending shear failure mode in beams, axial failure in column and cracks in connection. The elevated water tank is one of the affected structure caused by an earthquake and it is necessary to be functional after a severe earthquake for suffering from post-earthquake fire and for others domestic purpose. These study reports present the analysis and design of modal analysis, response spectrum and time history analysis of an elevated water tank using SAP2000 as a software analysis. The water tank is subjected to a dead load, live load, self-weight and seismic load. A seismic load calculation is done by follow Eurocode 8 2004. The capital analysis gives the natural frequency of the structure and time history where define the behavior of the structure in certain time interval against various functions such as velocity, displacement, acceleration, shear force, and bending moment.

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## LIST OF SYMBOLS

| | |
|---|---|
| Hz | Haze |
| m | meter |
| $m/sec^2$ | meter per second square |
| $m^3$ | meter cubic |
| g | gal |
| kN | Kilo Newton |
| Kn.m | Kilo Newto.meter |
| Km | Kilometer |
| Mw | Moment magnitude |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| DL | Dead Load |
| LL | Live Load |
| EL | Earthquake Load |
| MMD | Malaysia Meteorology Department |
| PEER | Pacific Earthquake Engineering Reserach Center |
| RC | Reinforced Concrete |
| 2D | 2 Dimensional |
| 3D | 3 Dimensional |

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

Reinforced concrete (RC) elevated water tanks a critical structure that is expected to remain functional after severe earthquakes in order to serve the water system network. Elevated water tank is a water storage transportation supported by a tower and constructed at an elevation to provide utility storage and pressure for a water distribution system. It holds a huge mass of water over a staging which is most critical condition during an earthquake. These structure depends on hydrostatic pressure produced by an elevation of water and thus are able to supply water even during power outages. Water storage tank should not collapse after an earthquake because it's being an important element in human lives that can be used in essential as a provider of potable water as well as quenching fire operations. Water storage tank has does not carry up to the possibility of some of the earthquakes in the past. Their safety performance is a critical concern during the strong earthquake due to a shortage of water for drinking or distressing in quenching fire during a critical situation, by collapsing of this structure and falling down of water perils occur for people and their health in the city.

An earthquake is a ground shaking produced by an instant slip of error that can impact any location at any times where stresses on the outer layer push off the surface of the fault together. Therefore, the expanding pressure and the rocks move abruptly, make it releasing some energy. The energy was called seismic waves that travel through the earth’s crust. It causes a tremors where anyone can address it during an earthquake. Earthquake is one of the most important and common phenomena of natural disaster that directly affect human life and property.

During an earthquake, building will tend to vibrate around one certain frequency known as natural frequency. According to the sudden movement, it poses a great pressure for the elements of elevated water tank structure including beams, columns, walls, and floors, as well as the connectors that hold these elements together. If they are firmly large enough, it can collapse or may cause damage to the structure of elevated water tank. Experience has shown that for new constructions, creating seismic resistant regulations and its implementation is critical protection against earthquake damage. With respect to existing structure, it is necessary to assess and strengthen it based on assessmemt criteria before the earthquake.

## 1.2 PROBLEM STATEMENT

The damage of structures induced by earthquake ground motions depends primarily on three parameters which are the characteristics of earthquake source properties and ground motions, the properties of the structure and how close the structure's fundamental natural frequency to the dominant frequency of the ground motion. 2011 off the Pacific coast of Tohoku earthquake has demonstrated these facts clearly. In general, the characteristics of the earth's motion involve uncertainty that exists and cannot be operated while its structural properties have lesser flexibility and can be dealt a little bit in general. For example, construction material and construction personnel can be selected and the seismic resistance of the structure can be increased to a high enough level through members detailed for increased ductility capacity.

Malaysia can be said to be free from earthquakes and categorized in low seismicity groups but still feel the tremors in certain places. Sabah and Sarawak often experience earthquakes as compared to Peninsular Malaysia. The magnitude 4.0 earthquake struck Mount of Kinabalu, about 16 km west of Ranau at 9.39am, June 28$^{th}$ 2016 on Friday, according to the Malaysian Meteorological Department website. Seismic damage affects buildings and infrastructure with high damage and death. Most buildings are designed only by considering wind effects rather than seismic effects. Therefore, the seismic effect should be considered since the small disaster has taken place.

Malaysia is located between 3 major tectonic plates namely Eurasian-Sunda plate, India-Australia plate, and Philippine-Pacific plate as shown in Figure 1.1. Remote earth movement has been recorded by Malaysia's seismic station network, from the two most active plate tectonic margins in the world, for example the Sumatera subduction zone, and the long 1650 km of the Sumatran axis, and the same Philippine plate.

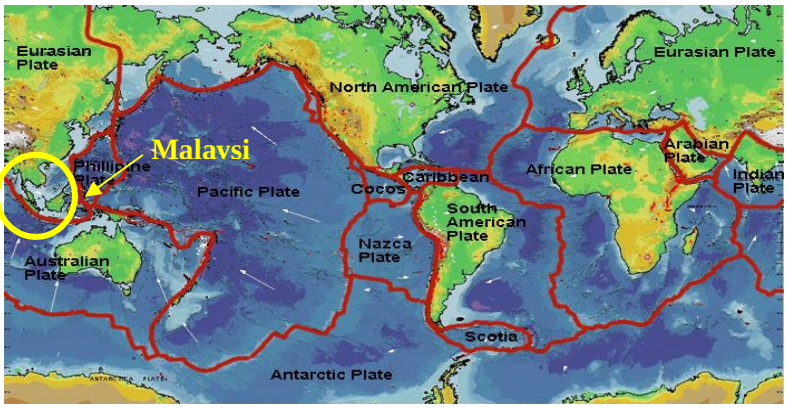


**Figure 1.1:** Major tectonic plates surround Malaysia.

Source: classified-blog.com [Online image]. (2016). Retrieved November 5, 2016 from http://classified-blog.com/photogms/usgs-plate-boundaries

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